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Pattern of urban land-use change and urbanisation dynamics in Ede, Nigeria

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ABSTRACT

This study analysed the growth and development of Ede, Nigeria between 1966 and 2020. The study assessed the spatial and temporal patterns of urban expansion; and identified the major drivers of urban expansion in the study area. The study utilised data collected through the use of inventory data sheets and handheld Global Positioning System (GPS) for ground truthing. Also, data were obtained from topographical map and satellite imageries. Data were analysed using Remote Sensing and Geographical Information System (RS/GIS) tools and Analysis of Variance (ANOVA). Results showed that Ede has greatly grown and developed since 1966 at an annual growth rate of %. Moreover, results indicated that the growth patterns identified in the study area did not conform to any of the single known theories of urban growth but, rather a combination of both concentric and sectorial patterns. Furthermore, the study found that improved socio-economic activities, expansion of the residential areas, and establishment of higher educational institutions were the major drivers of growth in Ede. While the study appraises the practicality of growth centre strategy to urban development, it harangued the unrestricted nature of urban expansion in the study area. Nevertheless, the study underscores the relevance of top-down approach to the growth and development of the study area. The study recommended the implementation of planning controls to aid well-defined land uses in the study area.

Key Words: Urbanisation pattern, urbanisation dynamics, digital representation, spatial planning; top-down approach; urban expansion; Ede

1. INTRODUCTION

The need to understand the patterns and dynamic processes of urban growth is borne out of the fact that the effects of urbanisation have become global prodigies and that urbanism has changed attitudes of urban dwellers toward values (UN-Habitat, 2012; Watson, 2014; United Nations, 2015). Hence, urbanisation as a process of settlement transformation, is an important attribute of development (Parker, 2015; Hanna, 2017; Tomlinson, 2017; Chapman & Dutt, 2018). The product of this transformation is the growth of urban centres (Mabogunje, 2015; Mcdonald, 2017; Fox *et* al., 2018).

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However, urbanisation does not only imply increase in number of urban people and increase in the number of urban centres but also to comprise the transformation between the rate of urbanisation and urban growth rate (Zhao *et al*., 2015; Alnsour, 2016; Bocquier, 2017). So, the application of digital representation as innovation in spatial inquiries has been greatly underscored (Dewan & Yamaguchi, 2009; Sun *et al*., 2014; An *et al*., 2018; Sumari *et al*., 2020; Hamud *et al*., 2021). There has been increasing demands in urban planning for coordinated application of Remote Sensing and GIS for sustainable development of urban areas (Yikalo & Pedro, 2010; Small *et al*., 2015; Dereli *et al*., 2017; Yang *et al*., 2019; Otokiti *et al*., 2021).

The spatial development of urban centres is central to spatial planning which, in turn, determines their sustainability. Thus, it is necessary to constantly update studies on urban and urbanisation. Changes in land use and land cover are very essential in studies concerning urbanisation and its related processes (Dahal, 2021). Urban land-use change implies the alterations that occurred on land (and its resources). The changes are brought about by activities that directly interfere with the natural landscape settings (Caldieronet al., 2017; Bose & Chowdhury, 2020; Naikoo et al., 2020; Sun et al., 2020; Agariga et al., 2021). Patterns of urban land-use change has been widely studied across the world (Liu et al., 2005; Zhao et al., 2015; Akintunde et al., 2016; Wang et al., 2020). Also, there is an abundant of studies on the determinants of urban land-use change (Yin et al., 2011; Li & Gong, 2016; Zhang & Su, 2016; Habila, 2018; Vivekananda et al., 2021). Furthermore, studies have been carried out on the complexity of urbanisation dynamics (Masek et al., 2000; Alnsour, 2016; Hu et al., 2016; Liu et al., 2016; Wang & Maduako, 2018; Zhao et al., 2019).

In Nigeria, several studies have been conducted on urbanisation dynamics Adegboyega & Aguda, 2010; Ujoh *et al*., 2010; Tope-Ajayi *et al*., 2016; Habila, 2018; Olayiwola & Lawal, 2018). Also, there are numerous studies on the possibilities offered by GIS, multi-temporal remote sensing data and ground data collected by global positioning system (GPS) to analyse the evolution of urban sprawl and their efficiencies in facilitating urban planning (Eke *et al*., 2017; Ogunjobi *et al*., 2018; Obiahu *et al*., 2021). Furthermore, several scholars have demonstrated how Remote Sensing and GIS tools can be used to measure rate and pattern of change in urban land use and urban growth especially in an unplanned traditional settlement (Akintunde *et. al*., 2016; Chima *et* al, 2018; Musa *et* al., 2018; Olorunfemi *et* al., 2018; Wang & Maduako, 2018).

In spite of abundant studies on urbanisation, yet, the temporal and spatial challenges created by urban dynamics are daunting. Hence, the study of urbanisation and urban milieus are living issues that require constant updating (Song *et al*., 2016; Hemba *et* al., 2017; Chapman & Dutt, 2018). Thus, this study presents an attempt at monitoring growth and development of an ancient urban centre in the South-western part of Nigeria through time. Ede is an ancient settlement which is almost forgotten in settlement or urban studies; there is no known published study on the urbanisation of Ede, Nigeria. It is hoped that by creating an image time-series, the topographical map and Landsat archives may be applied to trace the growth and development of Ede, Nigeria and evaluate the dynamics of urban expansion in the study area. These were with a view to understanding its urbanisation pattern.

The Study Area

This study was conducted in Ede, an ancient town that holds prime place in the history of Yoruba, Nigeria. Ede is bounded by longitudes 4º 27'E and 4º 34'E, and latitudes 7º 41'N and 7º 56'N (Fig. 1). There are two LGAs within the township of Ede; Ede North and Ede South.

Ede is in the tropical region characterised by high temperature and high rainfall. The rainy season starts in late March and lasts till October. The harmattan is felt between December and January. The native vegetation of the area is tropical rain forest. However, most of the area is now covered by secondary forest and anthropogenic vegetation (Salami, 1998; 2001). Ede is underlain by three rock types: pegmatite and schist, pegmatised (Adediji & Ajibade, 2005; Akintola *et al*., 2013; Adewale *et al*., 2017). The relief of Ede is gently undulating dotted by low hills, which range between 240m and 450m above the mean sea level. Ede is well drained with a many streams and rivers prominent among which include River Osun (the longest and the most permanent) and Erinle, a major tributary of Osun, which is dammed to supply portable water to more than 200 towns and villages in 20 LGAs across Osun State, Nigeria (Audu *et al.* 2015; Osun State Government, OSG, 2017). The main agricultural products are sugarcane, plantain, cassava, cocoa, melon, kola nuts, maize and palm that are produced in large quantities (Salami, 2001; OSG, 2017).

Ede is populated mainly by Yoruba and is thus unified by a general language. But within the population, there are groups associated with some dialects of Yoruba language (National Geospatial-Intelligence Agency, NGIA, 2017). Also, there are people from other parts of the country including Hausa, lgbo, Urhobo, Fulani, Tiv and Nupe (OSG, 2017). The socio-cultural and economic activities in Ede are reflections of its environment (Oyeweso, 1999). Though Ede is not highly industrialised, but can boast of a few large industrial establishments such as Cocoa Products Ltd. and some cottage industries like soap and cream, leather works, tie and dye, weaving, and ceramics units. Others are fruit juice, sachet/table water, school chalk and sacks. Traditional craftworks include brick moulding, goldsmithing and blacksmithing. Agro-allied industries like oil palm and cassava processing units are located at

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the urban fringe of the town. With regards to education, there were two private universities, a Federal Polytechnic and a College of Education. Also, there are other two private universities that are yet to commence academic programmes.

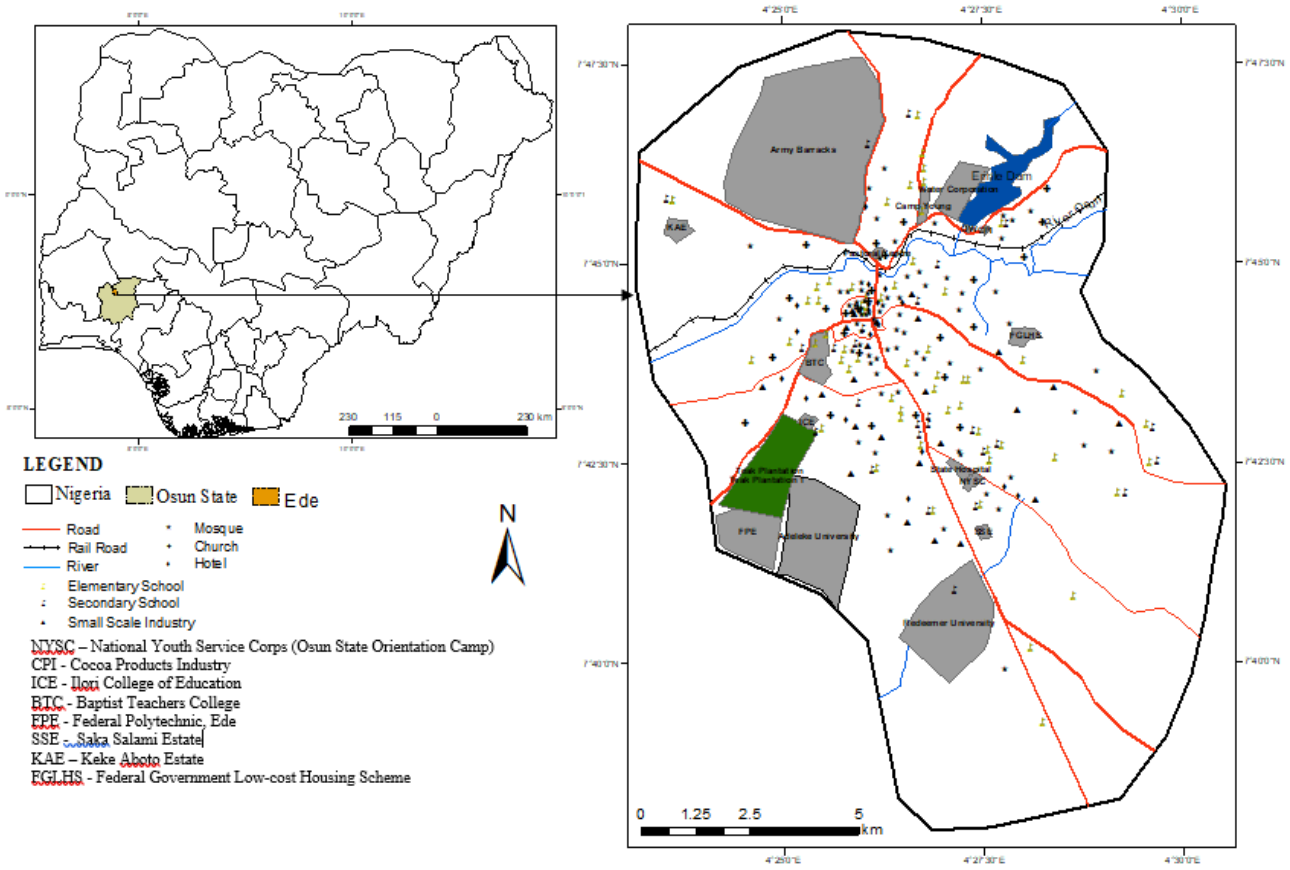

Figure 1: The Study Area

2. MATERIALS AND METHODS

2.1. Data Sources and Acquisition

Data for this study were gathered from both the primary and secondary sources. Primary data were collected using inventory data sheets to gather information on the socio-economic functions within the study area and ground truthing with the aid of handheld Global Positioning System (GPS). Secondary data were extracted from Topographic Map (Sheet 242 SE, 1966); Landsat 5 MSS/TM (January 9, 1986), Landsat 7 ETM+ (January 15, 2006), and Landsat 8 OLI/TIR, 2020 (February 2, 2020); administrative map of Ede; and Google Earth map (accessed, September 12, 2020). While the administrative map of Ede was used to identify and map-out the study area, topographical map and the imageries were used to trace and map out the spatio-temporal growth extent of the study area. Table 1 shows the characteristics and sources of the data used.

Table 1: Characteristics and Sources of Data

Data	Year	Resolution	Scale/Path & Row	Source	Band
Topographical map	1966	N/A	1:50,000	Dept. of Geography, OAU, Ife	N/A
Administrative map of Ede	2014	N/A		Planning Division of Ede South LGA	N/A
Google Earth map	2020				
Landsat 5 MSS/TM	1986	28.5m	Path 190, Row 55	http;//glcf.umiacs.umd.edu	5,4,3
Landsat 7 ETM+	2006	28.5m	Path 190, Row 55	http;//glcf.umiacs.umd.edu	5,4,3
Landsat 8 OLI/TIR	2020	28.5m	Path 190, Row 55	http;//glcf.umiacs.umd.edu	5,4,3
Population data	1991	N/A	N/A	NPC, Nigeria	N/A
	2006	N/A	N/A	NPC, Nigeria	N/A

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GPS Coordinate	2020	N/A	N/A	Ground Truthing	N/A

Notes:

OAU, Ife: Obafemi Awolowo University, Ile-Ife

NPC, Nigeria: National Population Commission of Nigeria

N/A: Not Applicable

2.2. Data Processing

2.2.1. Image Validation and Accuracy Assessments

In the attempt to assess the accuracy of urban growth map of the study area, two validation exercises were conducted. First, to estimate the remaining amount of background speckle (errors of commission or false positives), visual inspections (ground truthing) were conducted. All growth pixels representing errors of commission were considered; summing these pixels produced an estimate of the frequency of speckle within the growth map for each change epoch (Before 1966, 1966 – 1986, 1986 – 2006, and 2006 – 2020 epochs).

The second approach involved labelling urban growth by inspection. The assessment was aided by using high resolution Google Earth map to identify structures. Thus, treating the validation areas as ground-truth, a random set of validated pixels with the corresponding automated classification was compared.

2.2.2. Spatio-temporal Pattern of Urban Expansion

By this, a supervised classification of the study area was carried out through visual interpretation of the satellite imageries. Sections of the satellite imageries that represent pure endmembers according to the classes of land use/cover of choice were selected and digitised. An on-screen digitizing of these homogeneous pixels was used to create the vector layer for each of the land use/cover classes. These sampled sites were then used to develop signatures for further processes. Each classified imagery was disaggregated into different component land use/cover using attribute tool in ArcGIS, and maps representing dominant land use/cover class per epoch were derived. Thus, the spectral classes that were extracted from each Landsat scene were aggregated into three landcover types:

i. built-up (including high-density urban and residential areas);
ii. water bodies (including rivers, streams lake and dam); and
iii. unclassified (including outcrops and bare land, farmlands, vegetation and fields).

As a final step, isolated pixels (speckle), mostly associated with registration errors, were removed through majority filter. This procedure was repeated for all image pairs to produce the final growth maps of Ede, Nigeria.

2.2.3. Factors of Urban Expansion of Ede

All spatial processes in Ede were grouped into two broad classes. These are population growth and socio-economic activities.

Population Growth

In 1963, results of the national headcount in Nigeria were released on divisions and regional bases. Therefore, the population of Ede in 1963 included Ede Township and all other settlements that have organic connections and share historical background with it. As a result of this, the projected figures for 1966 and 1986 were affected by the group results. However, 1991 and 2006 censuses results were available at individual settlement basis (Table 2).

Table 2: Population Growth of Ede, 1963 – 2020

S/N	Year	Population	Percentage Change
1.	1963*	134,550*	-
2.	1966**	145,853	7.7
3.	1986**	253,384	42.4
4.	1991*	101,610	-149.4
5.	2006*	159,307	36.2
6.	2020***	240,967	33.9

Sources:

*National Population Commission of Nigeria, (NPC, 1963; 1991; 2006)

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** Projection at 2.8% annual growth rate (NPC, 1986)

*** Projection at 3% annual growth rate (NPC, 2016)

On a general note, the population growth of Ede can be summarized and grouped into three sections:

a. The population of Ede changed at increasing rates between 1966 and 1986; 1991 and 2020.

b. The population of Ede increased at diminishing rates between 1963 and 1966.

c. Decline or negative population growth occurred in Ede between 1986 and 1991.

Socio-economic Activities

All socio-economic activities considered in this study were categorised into seven sectors based on similarity of purpose and function (Table 3).

Table 3: Socio-economic Functions Covered by the Study

S/N	Sector	Spatial Processes and Functions
1	Agriculture	Agricultural Development Programmes, fish pond, poultry, cattle ranch and mechanized farm.
2	Commercial	Industries, banks, markets (open markets, lock-up-stalls and shopping centres)
3	Education	Pre-primary, primary, post-primary and tertiary institutions, library, unclassified schools (Arabic schools, nomadic school)
4	Health	Hospitals, clinics, maternities and dispensaries
5	Public Utilities	Administration (Local Government Secretariats and Zonal Headquarters), electricity (transformers), pipe-borne water (reservoirs), relaxation centres (rest-house and/hotel and tourist centres), defence and security (Police Station, Army Barrack, and Fire station)
6	Religion	Churches, mosques and traditional shrines
7	Transport	Road network, railway station, motor park, bridge, culvert and filling station

Total surveys were carried out on all the socio-economic structures in the study area. In each of the highlighted functions, both public (government at all tiers) and private (individual, community and corporate bodies and organisation) owned projects were surveyed. However, some socio-economic structures and activities were exempted from this study based on condition(s) specified against each of them.

a. Retail and artisan shops: these are too numerous and ubiquitous in the study area;
b. In-house and irregular religious centres: their specific locations cannot be ascertained;
c. Irregular school (extra-mural classes and regular schools) in unidentified locations;
d. Local craft industries: most of them were customarily inaccessible; and
e. Make-shift and portable kiosks: they are too numerous without permanent locations.

Frequency distribution and percentage mean score were used to assess the influence of the spatial structures and processes considered on the growth and development of the study area. In each of the sectors, total count of each structure was recorded and summed-up. The mean score, marginal increase and percentage increase were calculated separately for each sector. The mean scores for the seven sectors were aggregated for further analysis using Analysis of Variance (ANOVA). This made it possible to identify the major drivers of urbanisation in the study area.

3. RESULTS

3.1. Physical Expansion of Ede

All analyses in this section were based on the 62.5km^2 land area of Ede Township. The physical expansion of the study area was discussed under four phases. Phase 1 which occurred until 1966 when Ede was in a period of agrarian economy. However, other activities have started to spring up in Ede. For instance, railway line from Lagos passed through the town to the northern parts of the country in 1906 with a station in Ede. In the same year, the first bridge was constructed across Osun River. Many roads were constructed in this period both within the town and to link with other nearby settlements like Ara, Awo, Osogbo, Gbongan, Sekona, Ile-Ife and Erin-Osun. Also, several schools, health centres, hotels and religious centres were established in this period. There were

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expansions in commercial activities and human population, and consequently increase in residential houses. However, outside the well-defined contiguous built-up area there were other points such as educational institutions or distant residential housing units. The built-up area of Ede in 1966 determined from topographical map was about 4.4 km² (7%) of the total land area (Fig. 2a; Table 4).

Phase 2 occurred between 1966 and 1986. This period marked a great reduction in the proportion of farmland in Ede. The built-up area enlarged to 17.9km² at 306.8% rate of increase (Table 4). The newly introduced economic and other socio-cultural facilities were located along Osogbo and Ife roads (Fig. 2b). Thus, the pattern tends to follow the new order dictated by the axial corridors. Also, most of the residential buildings constructed in this phase were significantly different in quality from the previous ones. In addition, this phase marked the introduction of administrative function in Ede with the establishment of Ede Local Government Area in 1976. This new function required the use of more land for the construction of offices. Other striking developments in this phase were four private and one Federal Government Low-Cost Housing Estates. These schemes, located at the then outskirts of the town, increased the territorial boundary of the town (Fig. 2b).

The third phase of expansion occurred between 1986 and 2006. There was about 71.9% growth increase in the territorial extent of Ede in this phase (Table 4). The major physical growth machineries at this period are the permanent National Youth Services Corps Orientation Camp and expansion of two of the four existing private Housing Schemes. Others include the new Ede South Local Government Secretariat, few small-scale industrial plants and expansion of the residential area. The newly established Federal Polytechnic was located in the premises of the defunct Baptist Teachers' College. The period between 1986 and 2006 marked the beginning of serious landscaping and better planning controls in Ede. The growth pattern was still along the lines established in the second epoch (Figure 2c).

In the fourth phase, the settlement expanded further by 6.2km² resulting in a cumulative territorial extent of 33.8km² at the rate of 63.9% increase upon the previous epoch (Table 4). This implies that 33.8km² (representing 54.1%) out of 62.5km² of the total land area of Ede had been built-up by 2020 (Figure 2d). The major physical growth machineries in this phase were little developments in the newly established College of Education and two private Universities. There were diminutive expansions of the residential area to the North-east, East and South-eastern parts of the town. In addition to these sporadic developments was the opening-up of Ede South Local Government Housing Scheme at *Oke Iresi*. In sum, the period between 2006 and 2020 was majorly concerned with the improvement in the quality of the town's outlook, rehabilitation within the core area, better landscaping and improved planning controls. The growth pattern was still along the lines established since 1986 pattern (Fig. 2d).

Table 4: Physical Expansion of Ede Urban Area, 1966 – 2020

Period	Built-up Area (km²)	Cumulative (km²)	Rate of Increase (%)	% of the total Land Area (62.5 km²)
1966	4.4	4.4	-	7.0
1986	13.5	17.9	306.8	28.6
2006	9.7	27.6	71.9	44.2
2020	6.2	33.8	63.9	54.1

Sources: Topographical Map, Sheet 242, 1966
Landsat 5 MSS/TM, 1986
Landsat 7 ETM+, 2006
Landsat 8 OLI/TIR, 2020

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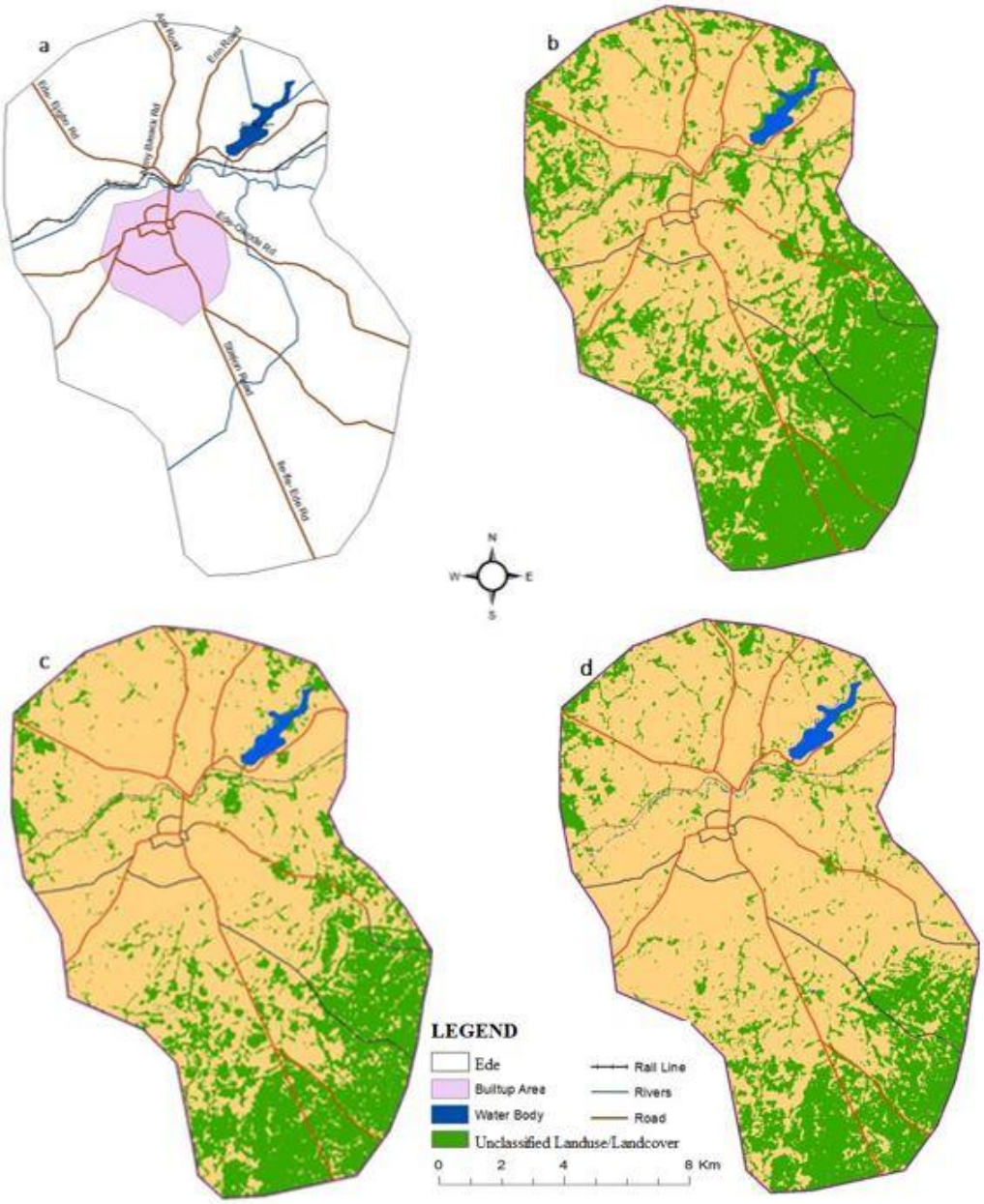

Figure 2: Growth Extent of Ede, 1966 – 2020 (a. 1966 b. 1986 c. 2006 d. 2020)

Sources: Topographical Map Sheet 242 SE, 1966
Landsat 5 MSS/TM, 1986 (January 9, 1986)
Landsat 7 ETM+, 2006 (January 15, 2006)
Landsat 8 OLI/TIR, 2020 (February 2, 2020)

3.2. Image Validation and Accuracy Assessments

Results of accuracy assessments for the classified Landsat images indicated that while the 2006 imagery had the lowest accuracy value (OA = 83.29; kappa = 0.719; z = 38.06), the best assessments were recorded for Landsat 8 2020 at OA = 94.38; kappa = 0.931; z = 41.64 (Table 5). These values indicate that there were high significant agreements between reference points and the extracted class (Cheng *et al*., 2019; Abbas & Jaber, 2020; Vivekananda, *et al*., 2021).

Table 5: Imagery Classification and Accuracy Assessment

LULC classes	Ground Truth Data	Classification Accuracy (%)					
		1986		2006		2020	
		UA	PA	UA	PA	UA	PA
Built-up	35	88.28	100.00	91.14	100.00	86.00	100.00

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Bare Land	8	100.00	85.00	100.00	96.67	77.50	91.31
Vegetation	28	84.80	91.78	89.03	80.23	100.00	100.00
Cultivated Land	25	81.45	87.51	70.90	76.74	100.00	95.09
Overall Accuracy		89.73		83.29		94.38	
Kappa (k)		0.817		0.719		0.931	
z statistics		46.19		38.06		41.64	

Sources: Landsat imageries (Path 190 Row 55)

Landsat 5 MSS/TM, 1986; Landsat 7 ETM+, 2006; Landsat 8 OLI/TIR, 2020

Note: PA = producer's accuracy, UA = user's accuracy

3.3. The Growth Pattern of Ede

Expansion of Ede did not conform with any of the popular growth patterns; it was a combination of some underlying principles of concentric zone with some others of the sectorial pattern. Generally, six distinctive zones were identified in the study area (Fig. 3). The identified patterns obeyed the rules of the concentric zonation theory put forward by Burgess (1925) in zones 1, 2, 3 and 6 while the sector's theory of Hoyt (1939) was clearly defined in zones 4, 5 and part of 6 (Fig. 3).

Zone 1 is the Central Business District (CBD). It is the oldest part and core area of the study area. The CBD covered about 8 km^2 (12.8%) of the total land area. The buildings are too closed together that easy thoroughfare between them is almost difficult. Although, the houses are of very low quality and built of poor materials, yet this part of the town is very important since it contains the seat of Ede North Local Government Area, palace, town hall, Divisional Police Headquarters, Postal and Telecommunication Services, seven daily and two periodic markets. In addition, the CBD is a zone of business activities where retail trading, artisan workshops, financial institutions and social facilities are concentrated. The residential houses were occupied by low-income earners and those bonded by the old family ties.

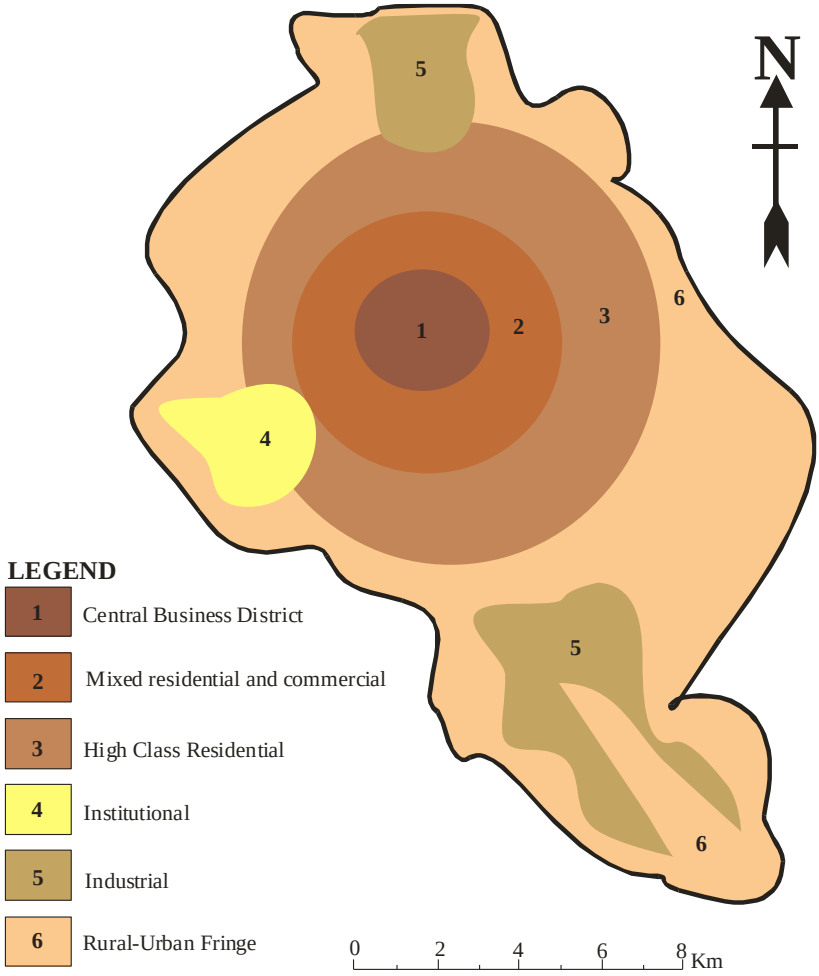

Figure 3: Growth Patterns of Ede

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Zone 2 which consists of mixed residential and commercial is the largest zone in the area covering about 15km² (24%) of the land area. This zone initially evolved as the outskirts of the old core but gradually became enlarged and developed to form a concentric ring around the CBD. The spatial structures are more organised with the introduction of some elements of planning. The greatest residents in this zone are the medium-income earners like the factory workers, civil servants, some successful retail traders, teachers and students of the Federal Polytechnic.

Zone 3 is a high-class residential area. It is a narrow zone which covers about 7.5km² (12%) of the total land area but contains high quality residential buildings. The streets are well-planned that every single housing unit is accessible by road. The zone was occupied by high income-earners like successful businessmen, tertiary occupation executives, high status public servants and other affluent individuals. Asides residential building, some primary and secondary schools, hospitals, Secretariat of Ede South Local Government, rest house and a few public establishments are found in this zone.

Zone 4 was deliberately carved out to constitute a separate zone based on the nature of land uses; it is tagged Institutional Zone. Asides little farming, this zone is largely occupied by educational institutions with very scanty residential buildings. The 15km² area of land representing 24% of the total study area comprised a Federal Polytechnic, Adeleke University, permanent site of the proposed Hijrah University, one College of Education, 9 secondary schools, 26 primary schools (including pre-primary sections).

Zone 5 is formed as a result of the linear expansions along radial corridors produced by road networks. It comprises of some industrial establishments which covered about 7km² (11.2%) of the total land area. Zone 6 was tagged "rural – urban fringe". This is the outer limit of the study area forming a concentric ring around the high-class residential zone but for the intervention of the two industrial axes. The borderlands of the study area are occupied by different kinds of agricultural activities and farm settlements of varying quantities but almost of the same quality. It covered about 10km² (16%) of the total land area.

3.4. Socio-Economic Growth and Development of Ede between 1966 and 2020

Table 6 shows the growth and development in the socio-economic activities of Ede between 1966 and 2020. Table 6 shows the ANOVA summary arising from Table 7 after been analysed by two-tailed Analysis of Variance.

Table 6: Growth and Development of Ede, 1966 - 2020

Sector	N	X	X^2	n	Y	$\bar{x}$	$\bar{x}^2$	$X(\bar{x}^2)$
Commercial	87	83	6,889	4	518.8	5.2	27.04	2244.3
Agriculture	53	51	2,601	3	425	4.3	18.49	943.0
Transport	90	80	6,400	6	330	3.3	10.89	871.2
Education	123	102	10,404	5	510	5.1	26.01	2653.0
Health	47	43	1,849	2	537.5	5.4	29.16	1253.9
Religion	181	133	17,689	3	1,108.3	11.1	123.21	16386.9
Public Utilities	146	134	17,956	15	223.3	2.2	4.84	648.6
Total	727	626	63,788	38	3,652.9	36.6	239.64	25000.9
					$\bar{X}$ = 16.5			

Source: Field Survey, 2020

N = total number of spatial structures existing under a sector in 2020

X = marginal increase in sector between 1966 and 2020

n = number of spatial processes considered in a sector

Y = % increase

x_i = sector mean

$\bar{X}$= grand mean

Table 7: ANOVA Summary of the Socio-economic Growth and Development of Ede

Source of Variations	Sum of squares	Degree of Freedom	Variance	F – Ratio
Between Group	14653.5	6	2442.3	F cal. = 1.95
Within Group	38787.1	31	1251.2	
Total	53440.6	37		F tab. = 2.74

Source: Computed from Table 3

The F - values (F – Calculated = 1.95; and F – Tabulated at 0.05% = 2.41) indicate that there has been significant growth and development in Ede between 1966 and 2020.

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4. DISCUSSION

The intricate dynamics involved in urban growth of Ede include socio-economic and physiographic considerations. The population of the study area has been growing at irregular rates (see Table 2). In 1963, the results released by the National Population Commission of Nigeria were based on major towns only; results of villages and all other settlements under a major (dominant) town were added together. Therefore, result of 134,550 in 1963 referred to Ede and its surrounding settlements. After 1963, there were three national headcounts in Nigeria; 1976, 1991, and 2006. The 1976 census results were rejected by the Federal Government of Nigeria based on widespread irregularities, data falsification, results manipulation and gross misconduct of the *ad-hoc* officials employed for the exercise. Hence, 1966 and 1986 populations of Ede were calculated based on the 1963 census results. Consequently, the drastic fall in the 1991 figure was because of the previous calculations based on 1963 divisional results.

The examinations and analyses of various spatial processes operating in the study area at four inter-temporal levels revealed that about 54% of the total land area of Ede has been developed. ANOVA test confirmed that the growth and development of Ede between 1966 and 2020 was not by chance. Analyses of the physical expansion of Ede indicated that the second phase of expansion occurring between 1966 and 1986 witnessed the greatest territorial expansion when a cumulative 17.9km^2 or 28.6% of the land area had been built up. In addition, the study found that the spatial structure of the study area did not conform to any of the well-known theories of urban growth: Burgess (1925), Hoyt (1939) or Harris and Ullman (1945) postulates. While the built-up area produced concentric patterns, the industrial establishments tend to follow the principal axial corridors initiated by the linear transport routes. From the analysis, it can be deduced that the major driving forces of urban expansion in Ede, Nigeria are:

i. availability of land for expansion;
ii. development of transport networks;
iii. educational development;
iv. expansion of administrative centres;
v. location and distribution of service centres;
vi. population increase; and
vii. expansion of commercial activities.

5. SUMMARY AND CONCLUSION

On a general note, the growth and development of urban centres is both complex and complicated. Taking an overview at the current trend of urban expansion in the world at large and Nigeria in particular, the need for proper urban planning becomes inevitable for efficient urban administration and control. Thus, Remote Sensing and Geographic Information System becomes a handy tool in providing up to date information required by planners and administrators.

The study of urbanisation dynamics of Ede, Nigeria entails a cross examination of the spatial processes that make-up the study area, both temporally and spatially. The spatial variation exits in effect of the locational and distributional patterns; some parts are abundantly catered for at the expense of others. The inter-temporal variations in the spatial processes enhanced spatial re-structure and re-organization as time progressed. This study used remotely sensed data to capture the nature and rate of expansion of Ede, Nigeria. This facilitated the synoptic analysis of the town's system, patterning and change. Hence, this study will provide substantial evidence that the application of remote sensing techniques in urban growth monitoring could provide fast and up to date information that can be used for city administration and effective planning of land cover for sustainable development. In addition, it will provide the potential interventions needed in sustaining the urban periphery. Hence, this study is expected to make the much-needed difference for hard-pressed planners in Ede, Nigeria.

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Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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